THE FREAKONOMICS OF PLANT PROTECTION: The Extended Version

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Freakonomics

- *Freakonomics* (S.D. Levitt and S.J. Dubner) presents examples of the "Law of Unintended Consequences" in everyday life, usually with the point being that people respond to incentives created by the systems/institutions we develop
  - Sumo wrestlers, school teachers, real estate agents
  - These lessons apply to agriculture and plant protection
- Provide examples from economics, with some historical context
  - Stories for your teaching and/or extension!
- Extended version of my talk at APS meetings

Quick Overview

- **Cornerstones of Freakonomics**
- 1) Conventional wisdom is often wrong
- 2) Experts use their information to their own advantage
- 3) Dramatic effects often have distant even subtle causes
- **Jevon's Paradox**
  - Impact of more efficient input technology on input use
- **Cochrane's Treadmill**
  - Impact of more productive output technology on producer profit
- **Asymmetric Information**
  - Crop consultants and IPM

Jevon's Paradox

- Concern about a resource becoming scarce
  - Modern examples: energy and water
- Development of a new, more input efficient technology
  - LED Lights
  - LEPA (Low Energy Precise Application) Irrigation
- Should reduce use of the resource (energy, water), right?

Jevon’s Paradox

- William Stanley Jevon’s book *The Coal Question* (1865)
  - England’s coal reserves rapidly disappearing, some argued that need to improve efficiency of coal machines to reduce consumption
  - Jevon’s Paradox: increasing efficiency lowers the effective price of the resource and may actually increase total use
  - Jevon saw Watt’s improved steam engine vs. Newcomen’s original design lead to more coal use in England
  - All depends on the price elasticity in the market for the final good
- May hear today when people talk about Energy Efficiency

  1) Increased efficiency lowers price of the work done by energy, so demand more work and hence more energy (intensive effect)

  2) Increased efficiency causes economy to grow, further increasing the demand for energy (extensive effect)

Jevon's Paradox in Agriculture: Irrigation and Water Use

- Water available for irrigation decreasing
- Respond by creating more efficient irrigation technology and/or incentive programs to encourage farmer adoption
  - Center pivot vs. gravity, drip or low pressure vs. center pivot, etc.
- Meeting crop water needs now cheaper

  1) Use more water per acre or plant crops that demand more water per acre, because now economical to do so (intensive)

  2) Expand irrigated area as it becomes more profitable (extensive)
- Total water use <u>may</u> increase: depends on price elasticity

Jevon's Paradox in Agriculture: Pest/Pathogen Control

- Develop a new higher efficacy pesticide that provides better control of some pest or pathogen
- Can imply
  - More/fewer treatments per acre (intensive)
  - More/fewer acres treated (extensive)
  - Expansion/contraction of acres devoted to the crop (extensive)
- Effect on overall active ingredient applied?
  - Problem of comparing/aggregating pesticide ai's

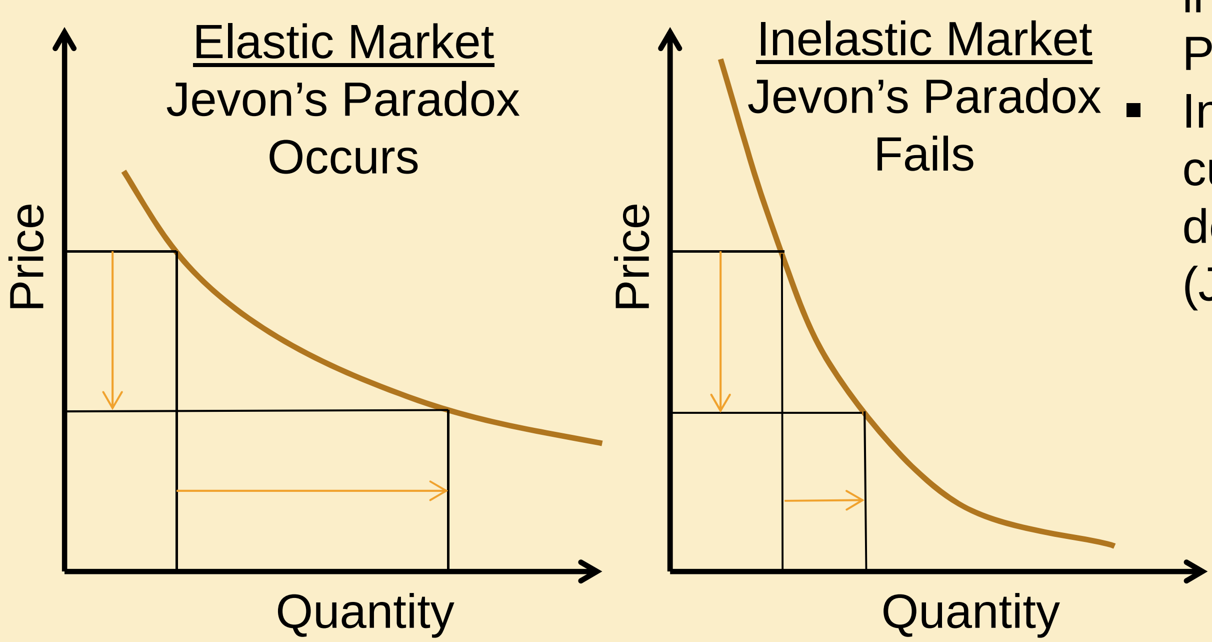
- What are the effects of Bt/RR crops on pesticide use and crop acres?

Effect of Input Efficiency Improvement on Resource Use

- Which effect dominates?
- Use less because more efficient technology
- Use more because of Intensive and Extensive Effects
- Depends on price elasticity in market for effective input
- Price elasticity measures how responsive the quantity demanded is to price changes ($\%\Delta Q/\%\Delta P$)
  - Determined largely by the slope of the demand curve
- 50% increase in efficiency means 50% price drop, how much does quantity demanded change?
  - > 50% = Jevon’s Paradox Occurs
  - < 50% = Jevon’s Paradox Fails

Efficiency Increase and Price Elasticity (Slope of Demand Curve)

- Think of the market for the effective input (not resource)
  - Work (not energy), irrigation (not water), pest control (not pesticide)



- Elastic (flat) demand curve means quantity demanded increases > 50% (Jevon's Paradox occurs)
- Inelastic (steep) demand curve means quantity demanded increases < 50% (Jevon's Paradox fails)

Questions?

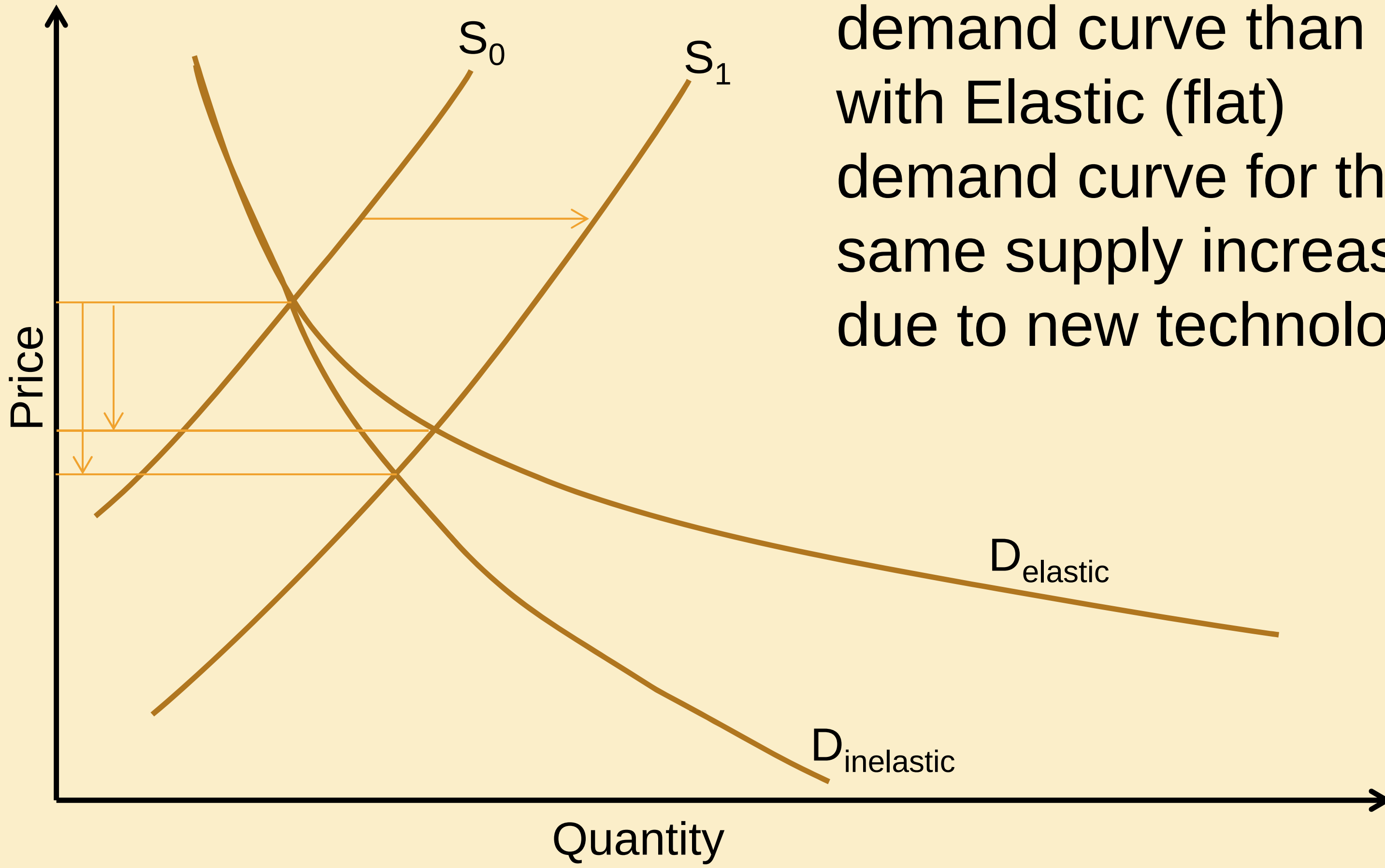
Cochrane's Treadmill

- New technology increases output productivity
  - Think crop yield increases
- Producers adopt the new technology
  - More output for same level of input use or lower cost to produce same output
- Producers should make more money, right?

Cochrane’s Treadmill
(Willard Cochrane, Ag Economist, U of MN)

- Producers adopt the new technology and make more money by selling extra output
- Problem: price effects offset some, or possibly all, of the benefits to producers, can even make producers worse off
- Supply increase causes output price decrease
- How much price falls is driven by price elasticity in output market (slope of demand curve)
  - Steep (inelastic) demand means large price drop (Cochrane's Treadmill occurs)
  - Flat (elastic) demand means small price drop
- Consumers always win with new technology: lower prices

Cochrane's Treadmill and Price Elasticity

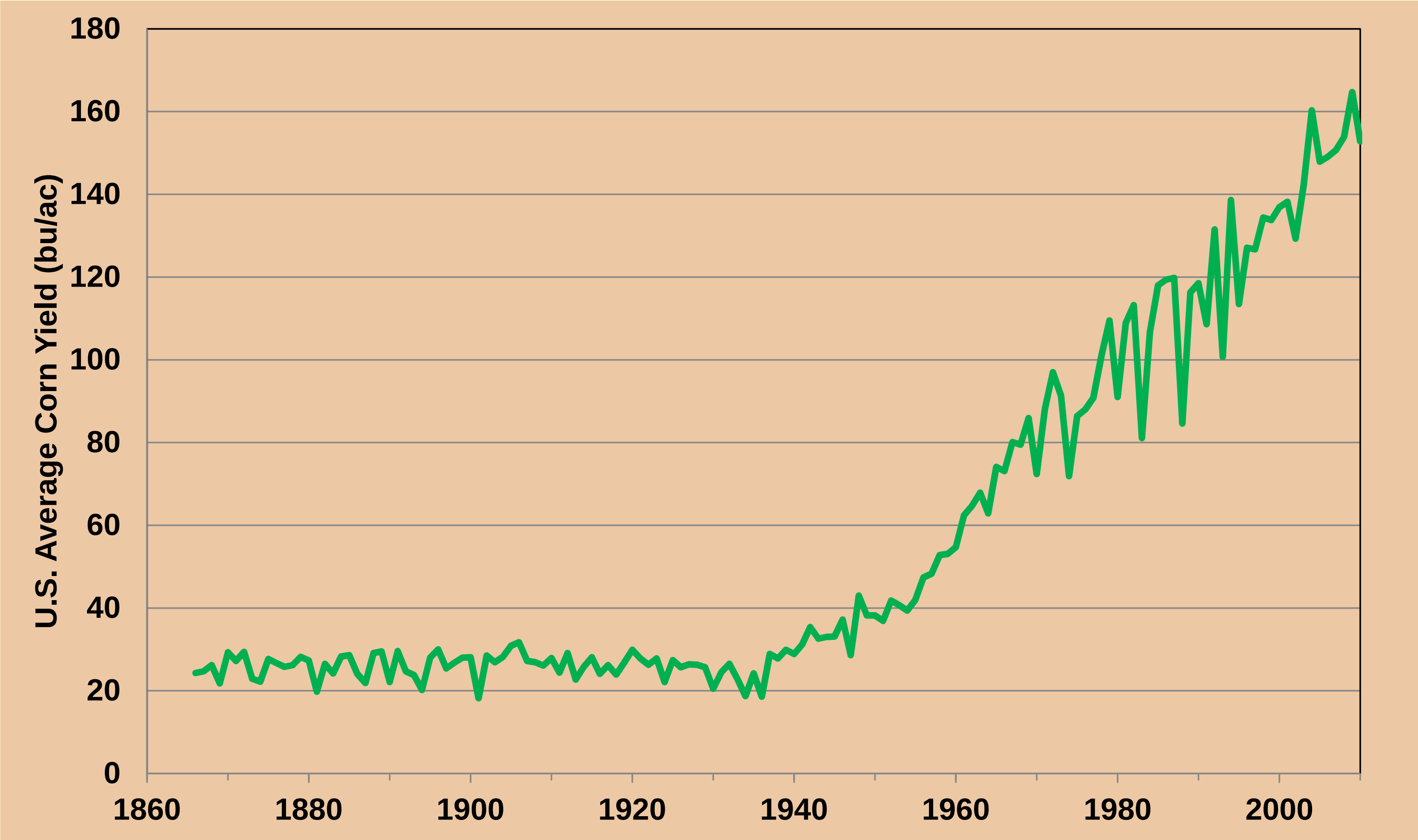


- Larger price decrease with Inelastic (steep) demand curve than with Elastic (flat) demand curve for the same supply increase due to new technology

New Technology and Cochrane's Treadmill

- Early adopters: Sell increased production at prevailing price, farm income increases, drive down market prices
- Later adopters: Farm income falls as prices fall, forced to adopt lower cost technology to survive with lower prices
- Farmers on treadmill – Always running to adopt newest technology to stay ahead of declining real prices
- Farm income distribution shifts to larger farms as small farms drop out, more rural inequality and poverty
- Many of us work on creating new technologies and encouraging/helping farmers adopt them
  - Is this a good thing for farmers? (For consumers?)

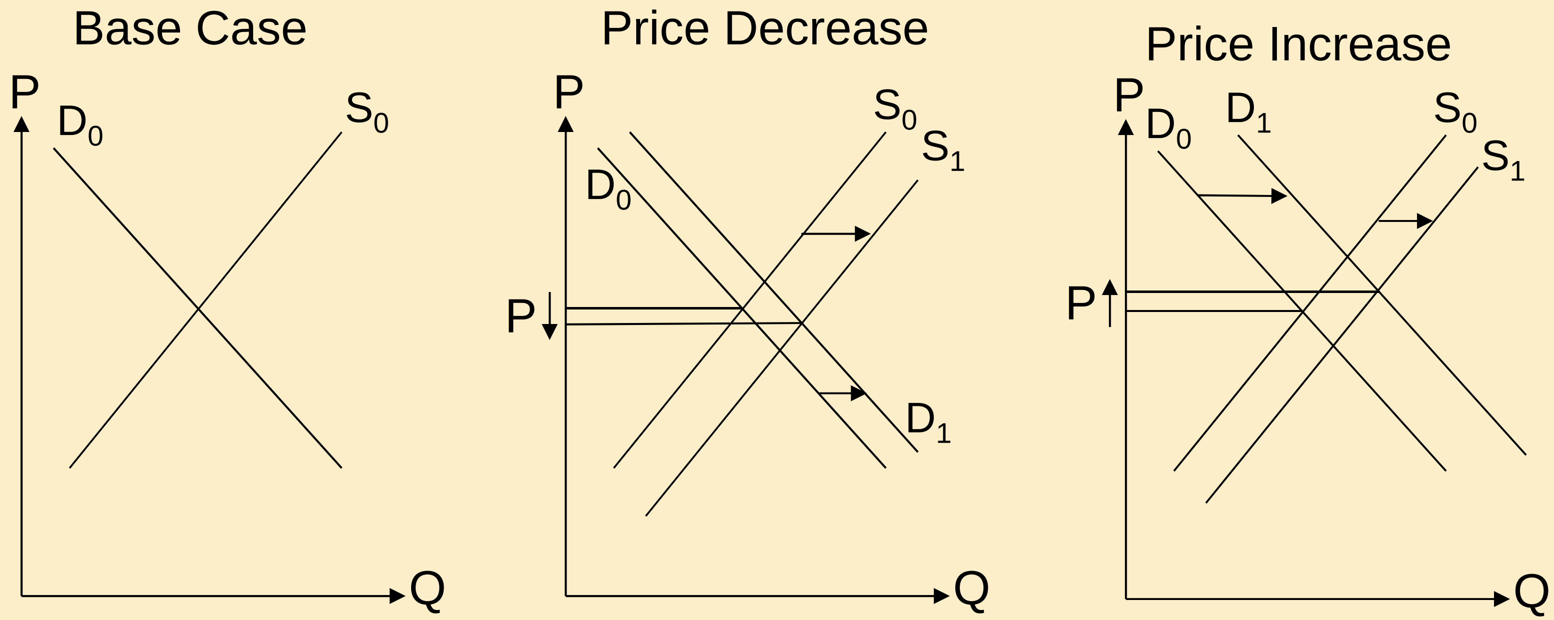
U.S. Average Corn Yields (bu/ac)



Technology Change and Consumer Demand

- Reality: there are confounding effects, not just supply changes, also demand changes
- Technology change increases supply (reduces cost per bushel): shift supply curve outward
  - Means drives prices downward
- Consumer demand increases with population and income increases: shifts demand curve outward
  - Means drives price upward
- Which effect wins?
  - Depends on elasticities and size of curve shifts

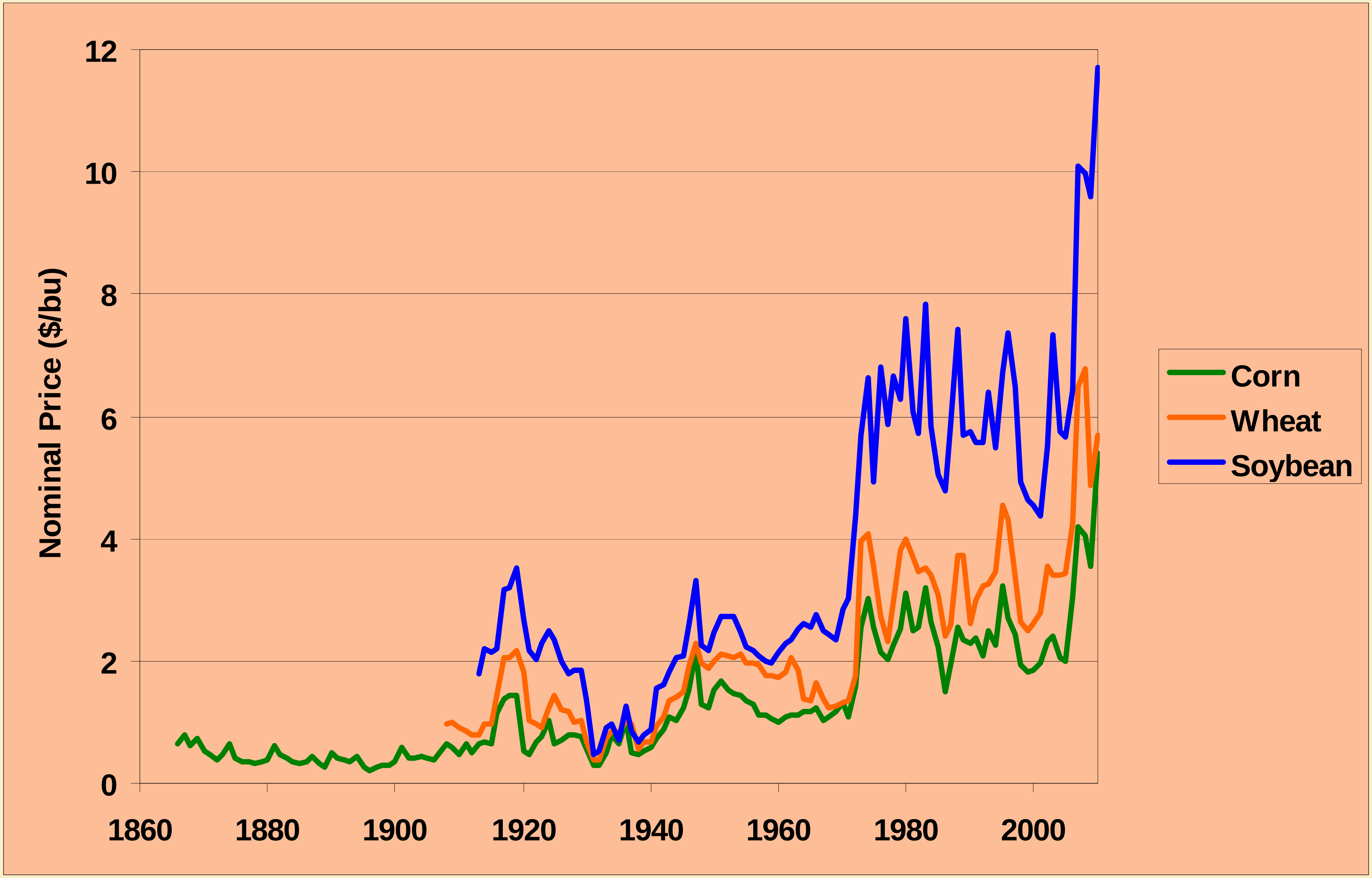
Changing Technology and Demand can lead to price increase or decrease



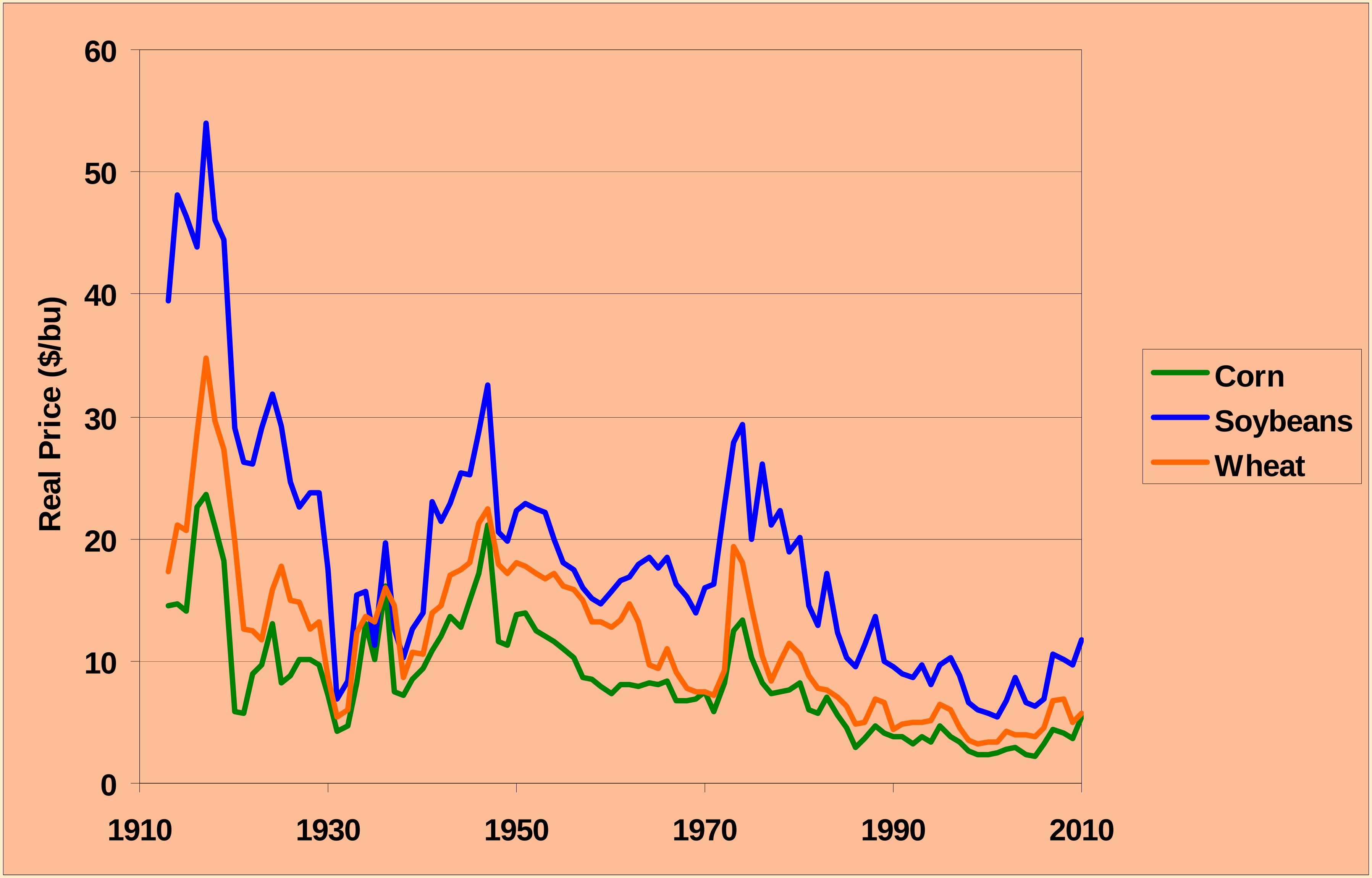
Price effect depends on whether supply or demand curve shifts the most, plus elasticities (slopes) of the curves

Which has dominated in USA?

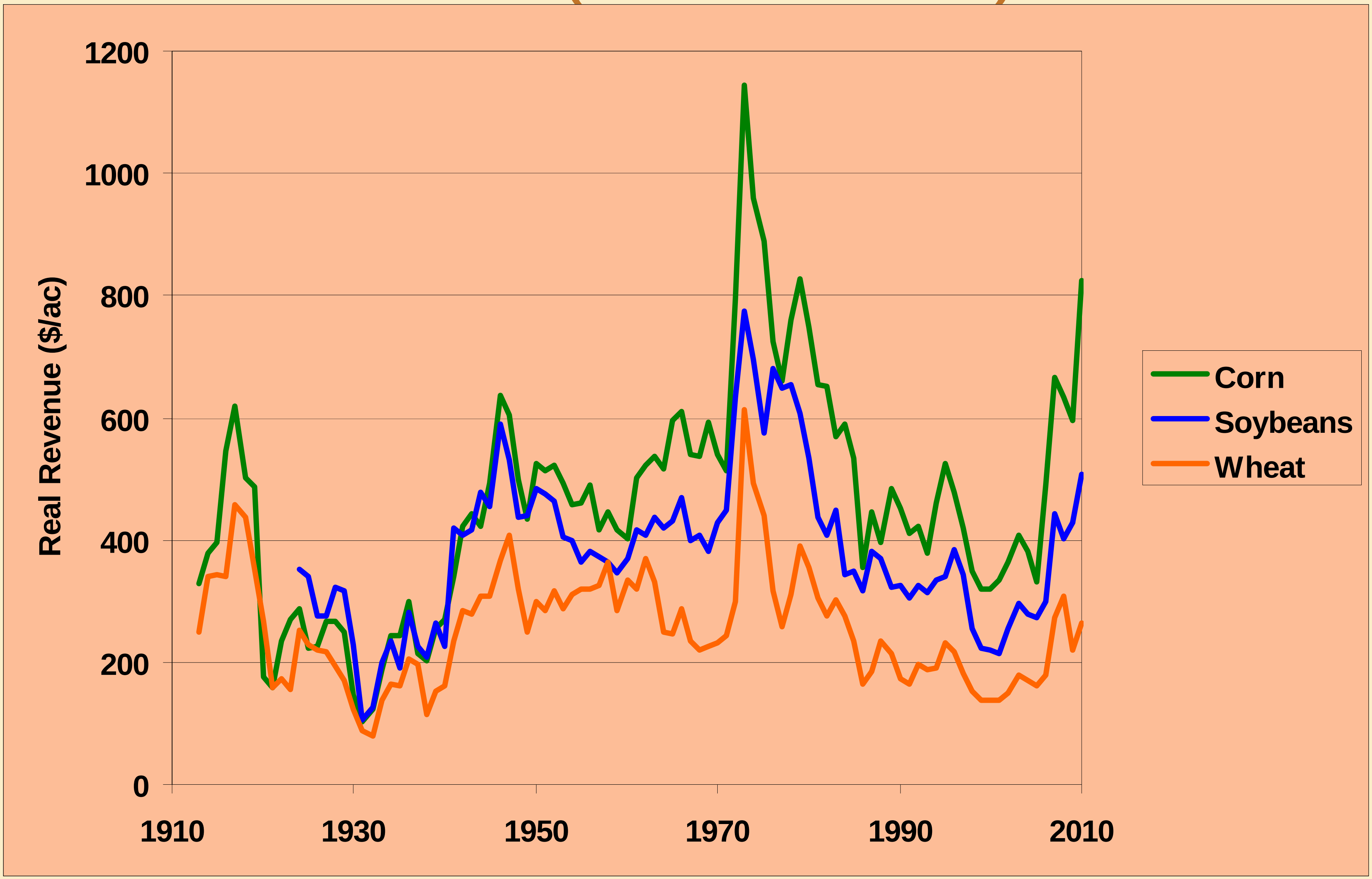
Nominal Grain Prices ($/bu)



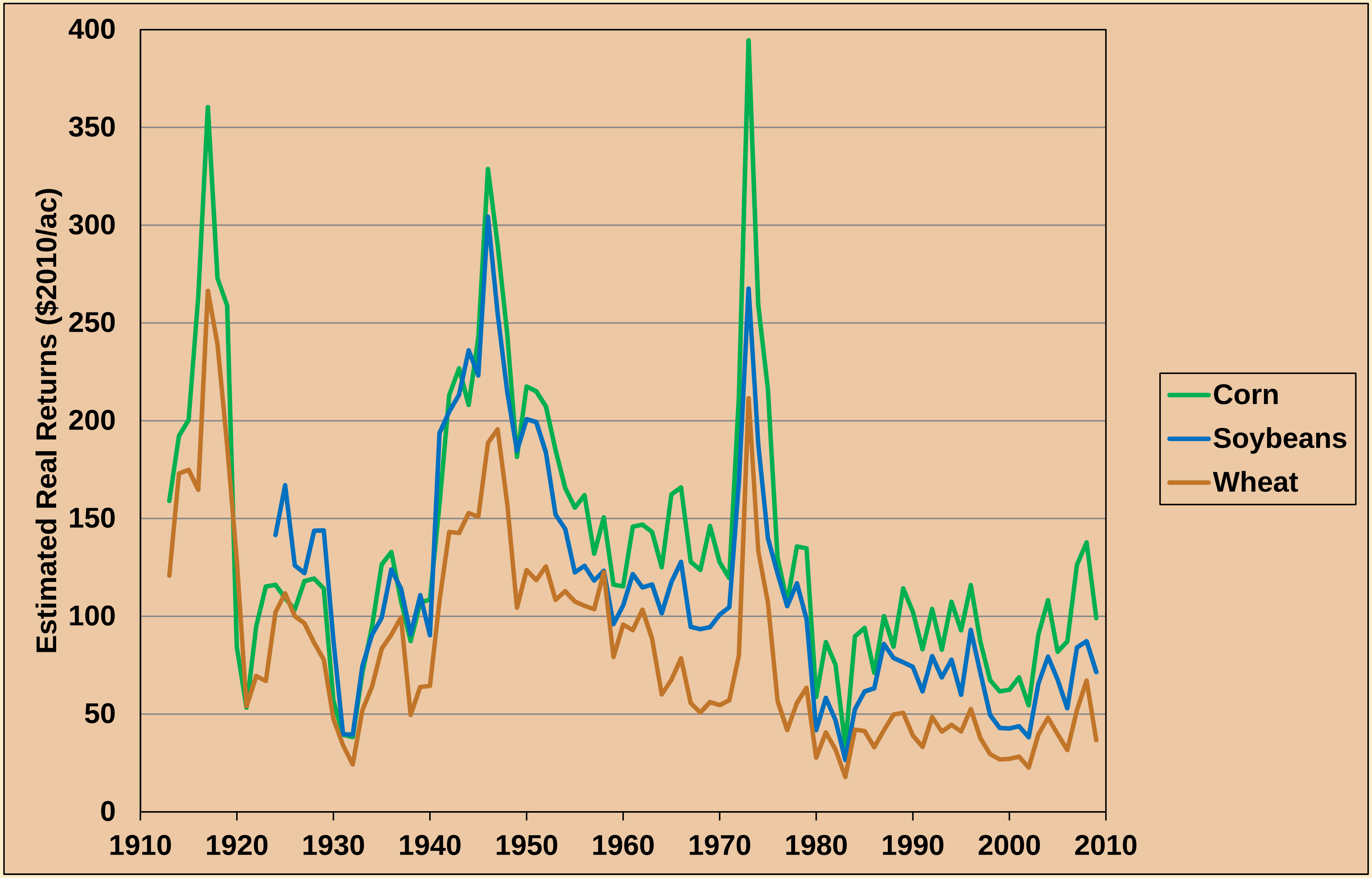
Real Grain Prices (2010 $/bu)



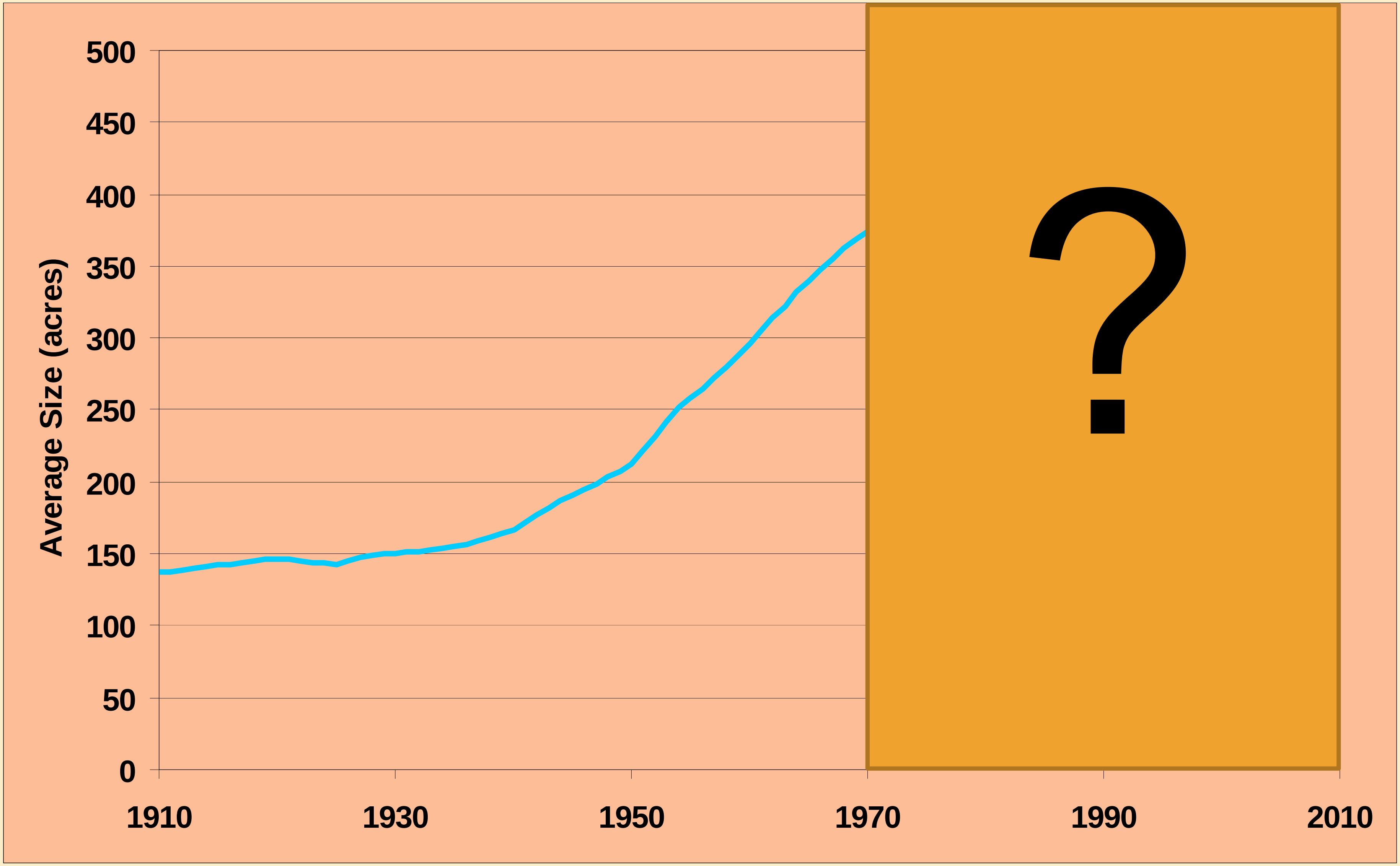
Real Revenue (2010 $/acre)



Estimated Real Returns (2010 $/acre)



Average U.S. Farm Size (acres)



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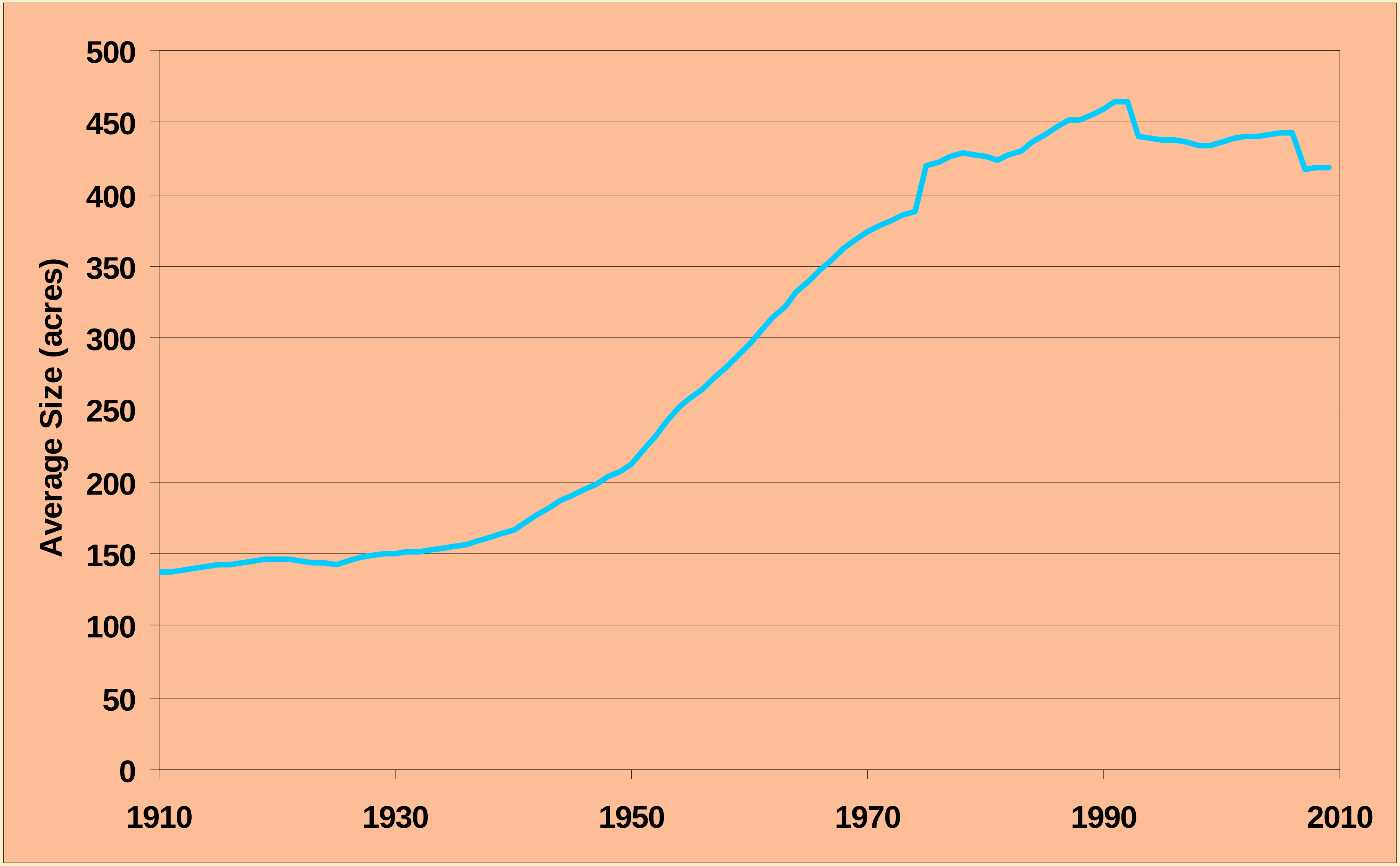
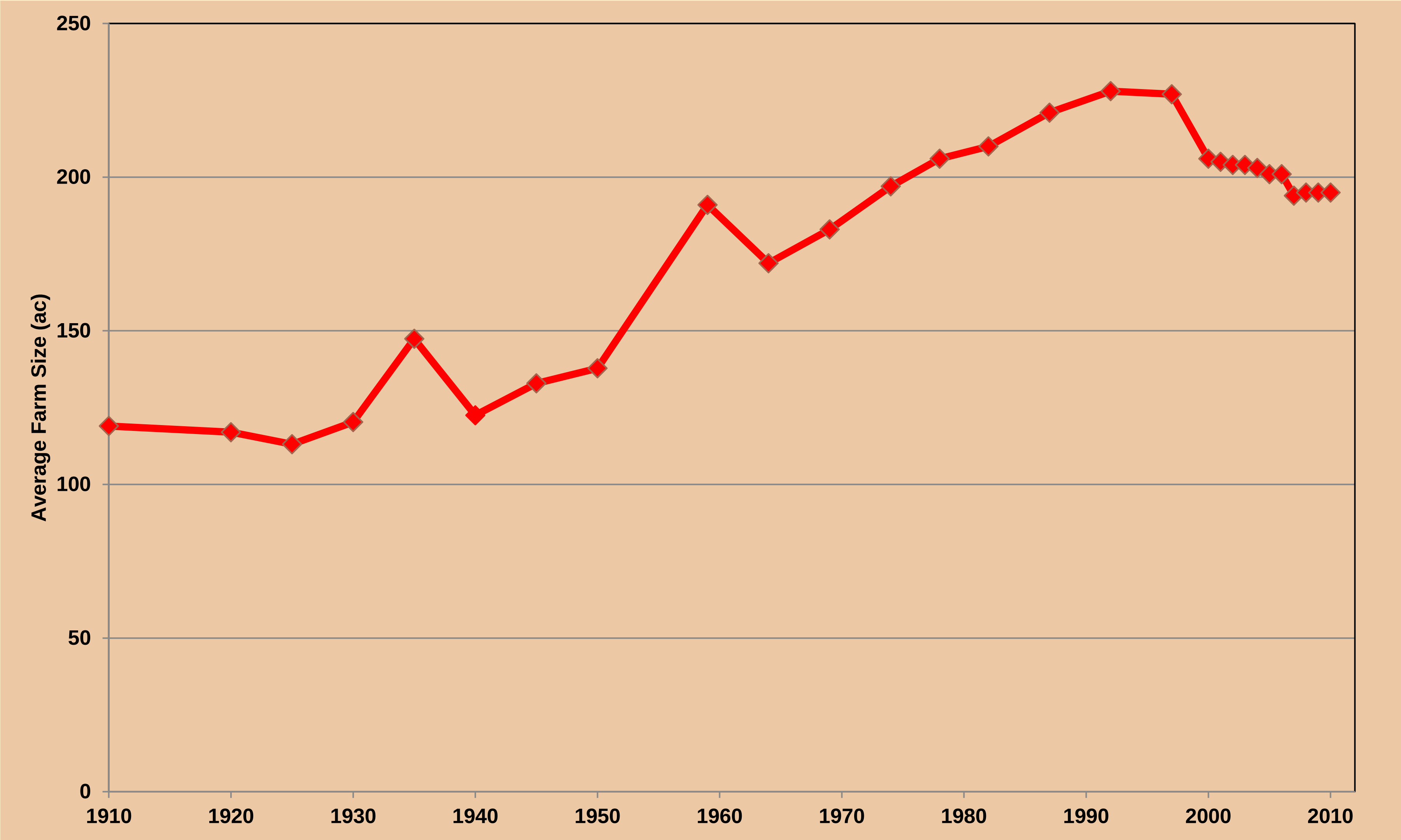


Average WI Farm Size (acres)

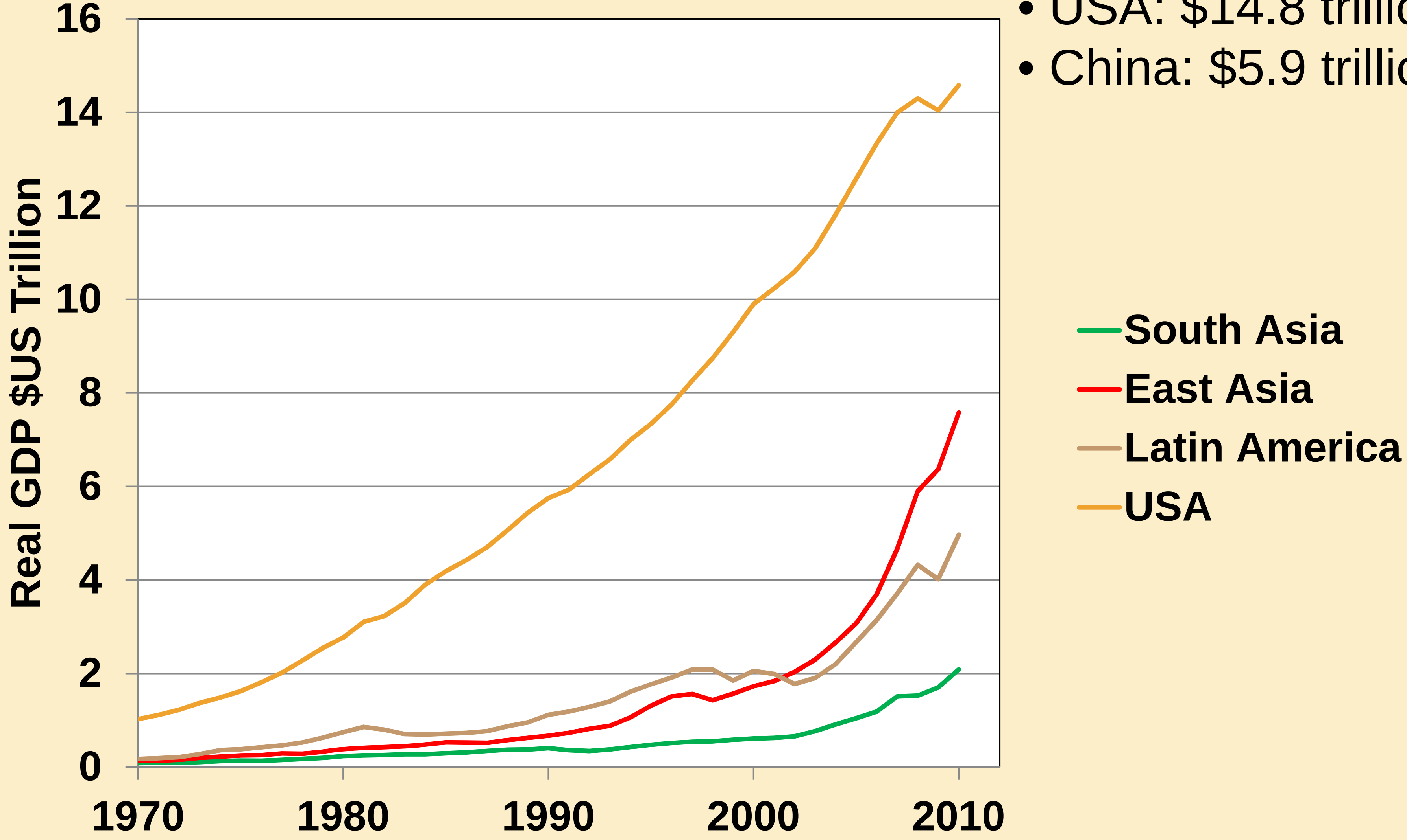


Cochrane's Treadmill

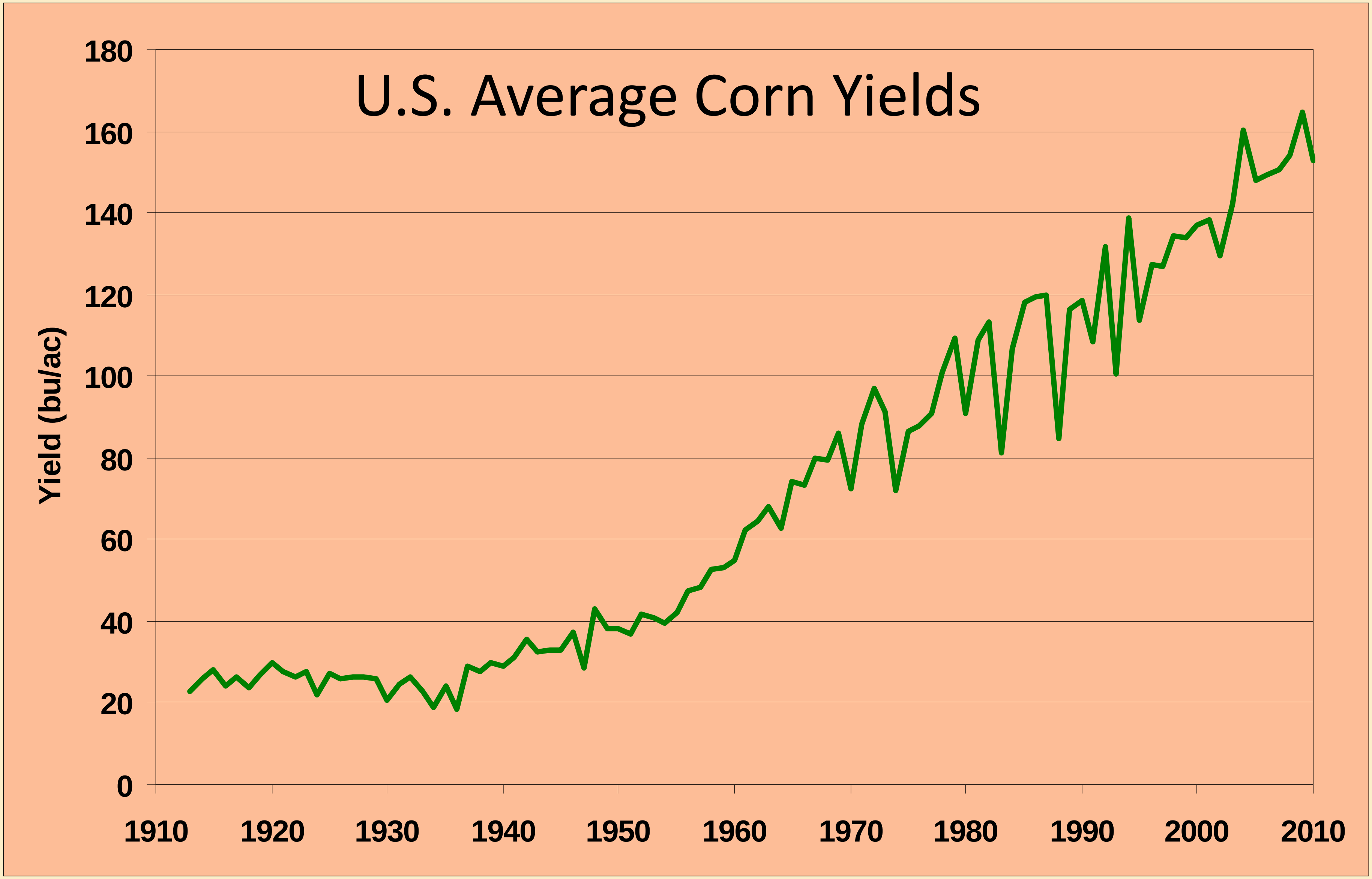
- For corn, soybeans and wheat, over the long run, farmers seem to be losing
  - Declining real prices, farm consolidation
- However, in recent years, real returns increasing and average farm size is constant/decreasing
- Is demand increasing faster than usual?
  - China/India effect?
- Is supply increasing slower than usual?
  - Are crop yield gains slowing?

Growth in Real GDP

- China became the world's 2nd largest economy in 2010
- USA: $14.8 trillion
- China: $5.9 trillion



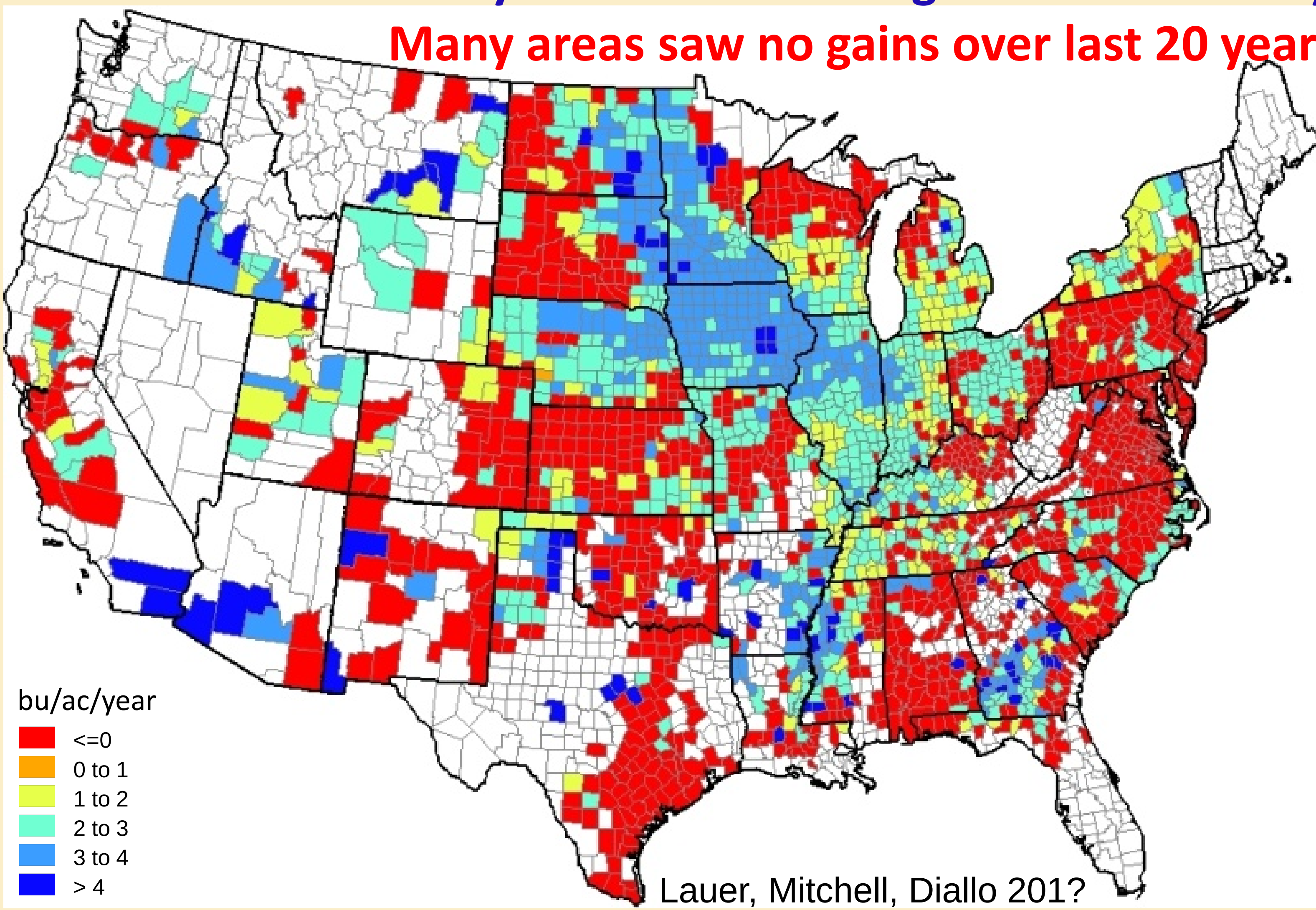
Has the rate of technological change slowed?



Rate of Increase for County Average Corn Yields 1990 to 2009

Many areas saw record gains over last 20 years

Many areas saw no gains over last 20 years



Farm Benefits of GM Crops with Price Effects

- Several studies examined in early years, focusing on late 1990 seasons, summarized in recent NRC report
  - Impact of GE Crops on Farm Sustainability in US (2010, p. 161)
- Who gets benefits varies among crops (Price et al. 2003)
  - Bt cotton: 1/3 farmers 1/3 innovator 1/3 consumers
    - Farmers got about $61 million or $29/ac
  - RR cotton: 5% farmers 5% innovator 90% consumers
    - Farmers got about $9 million or $6/ac
  - RR soybean: 20% farmers 70% innovator 10% consumers
    - Farmers got about $62 million or $5/ac
  - Recent years ??? Bt Corn ???
    - My own work on Bt corn is in preliminary stages, examining multiple years, plus include benefit of pest suppression

Cochrane's Treadmill

- Historically, supply grew faster than demand, falling prices
  - New technologies, including pest/pathogen control a major part of this supply expansion
- Were farmers better off? Farmer numbers decreased and farm size grew, declining farm income, migration from rural areas, social disruption
  - Developing nations have more empirical examples
- Currently demand growing faster than supply, rising prices
  - How long will this last?
- Average farm size actually flat/decreasing
- Farmers seem to getting a break from the Treadmill

Questions?

Asymmetric Information

- People with different levels of information making agreements with one another
  - Insurance markets, sharecroppers, lenders/borrowers, etc.
- Adverse Selection: people misrepresent who they are to get a better deal (i.e., borrowers, insureds)
- Moral Hazard: people act differently once they have a deal (i.e., insureds, sharecroppers)
- **Main Idea: People use information to their advantage**
  - Several Freakonomics examples
  - Several Nobel prizes in recent years (1996, 2001, 2007)
  - Large literature, major area in economics now, just give one interesting possible application in plant protection
- My research: Bt corn refuge compliance, SNAP benefits and healthy eating

Moral Hazard in Plant Protection

- When determining input use for many agricultural production processes, under use for many inputs is often obvious, while over use is not
  - Obvious if needed more fertilizer or should have treated for a pest/pathogen
  - Not obvious if applied too much fertilizer or treated for a pest/pathogen and did not need to
- Hidden over use problem combined with non-responsive yield at near optimal levels of input use
  - Over use of many ag inputs, un-used/wasted inputs
  - Input over use a hidden cost (inefficiency, lost income)
  - Unnecessary environmental problems result

Crop Consultants and IPM: Simplified Example

- Consultant scouts to observe early season pest population to estimate expected pest pressure and to make a treat/not treat recommendation
- Actual pest pressure is random, either low or high, but correlated with early season pest population
- Because of Hidden Over Use Problem, a consultant only looks bad when recommends to not treat and high pest pressure results (recommended "wrong" course of action)
- Farmer fails to see costly over use when consultant recommends treatment and low pest pressure results

	Low Pest Pressure	**High Pest Pressure**
Recommend Treat	"**Looks Good**"	Looks Good
Recommend Not Treat	Looks Good	**Looks Bad**

Crop Consultants and IPM

- Farmers tend to drop consultants who make “wrong” recommendations (i.e., have IPM failures)
- Consultants have an incentive to use lower treatment thresholds in IPM, so less likely to lose clients
  - Less likely to recommend not treat and high pressure result
  - IPM threshold set to maximize farmer’s returns, not consultant's
  - Consultant adjusts IPM threshold down to maximize his/her returns
- Solutions?
  - Equalize information: show farmers the scouting data and explain, so it’s a failure of IPM, not consultant (More costly consultant)
  - Leave untreated check (Often not possible)
  - IPM Insurance for farmer/consultant: pays indemnity if IPM fails (Too small of a gain for companies to profitably develop and sell)

Freakonomics of Crop Consultants and IPM

- Freakonomics often reports results of data mining/data analysis to support their arguments
- What sort of data analysis needed here?
- Data to show that consultants who are also farmers use higher thresholds on their own farms than on client farms
- Data to show that consultants use lower thresholds than farmers in the same region
- Likely noisy data, would need lots of observations
- Do such data exist???
- Alternative: survey of consultants and farmers, asking them what thresholds they use and why
  - Consultants misrepresent themselves on survey?

Summary

- **Jevon's Paradox**
  - More efficient input technology does not necessarily mean less use of the input
- **Cochrane's Treadmill**
  - More productive output technology does not necessarily mean higher income for producers
- **Asymmetric Information**
  - Do crop consultants use lower IPM thresholds?

Questions? Comments?

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